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Design and Implementation of a Low-cost IoT Smart Weather Station Framework

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Abstract

Monitoring systems have become more and more crucial in our lives in recent years. Consequently, we propose in this work an automatic weather monitoring system that is capable of obtaining dynamic, real-time climatic data for a given area. The Internet of Things (IoT), a sophisticated and effective method of connecting objects to the Internet, serves as the scientific foundation for this system. Many areas of practice and science rely on accurate climate measurements. Location and time of day influence weather factors, especially in tropical areas where there are no seasons. Furthermore, as precision agriculture or smart agriculture advances, it will be crucial to improve the measurement of systems that are widely distributed over growing areas. For these reasons, the design, building, and fabrication of a mobile air conditioner with Wi-Fi connectivity and solar energy power is presented in this work. This station measures both relative humidity and temperature. Additionally, workstations can be configured and managed remotely. The program's objective is to promote the creation of freely accessible, open-source hardware. A meteorological base station framework based on the ESP-32 Internet of Things device development board is proposed in this study. The system has a feature that records the ambient temperature and humidity. The ESP-32 web server then makes the data available to the user. A web page is also part of the system to make controlling adjacent instruments easier. The system gets its power from solar electricity.

Keywords: ESP-32, IoT, Cloud Computing.

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1 Introduction

An innovative technology that offers computer services to the Internet is cloud computing. Is able to be explained online. It doesn't keep any information on your desktop PC. When needed, computing resources including servers, networks, databases, and data storage. The primary goal of cloud computing is to enable people to access data centers (Shiraishi et al., 2011). Data can also be downloaded from a remote server. And please show his responses to the image has become good, friendly, environmentally friendly Innovation is improving day by day from automatic machines to customer products. These deployments' data encourage innovation and better judgment (Kashif et al., 2019). However, to ensure data gathering, installations frequently consist of heterogeneous sensor systems, like many IoT solutions. (Kollolu, 2020). today's metropolitan surroundings, the construction of smart cities is a fast-expanding trend. A smart city is one that maximizes the effectiveness of municipal operations and services by utilizing cutting edge technology, internet of things (IoT), and data analytics (Tekinerdogan, B., 2023; Priyanka et al., 2023). In terms of sharing their smart meter information with strangers that might be useful for them to better handle their energy consumption, customers are watching to do so. Customers have notably more confidence in utility service providers than they do in sales offers from strangers (Stevovic et al., 2023). As a result, utilities play an essential function in increasing the general population's information about how much energy they use. In any case, the lack of a modular messaging infrastructure means that utility companies may continue to operate like monopolies and exploit customers due to a lack of transparency. Moreover, the previous solutions do not scale in the range of more than two thousand users with restricted devices. Eager to make arrangements to direct devices to automate the home It preceded and enhanced the usage of energy. Nonetheless, handling the massive amounts of information in real time requires additional focus. Over the last ten years, the field of computer technology has been consistently striving to produce novel advancements. One of the major innovations that has changed the environment and continues to do so is cloud computing, which has turned simple tasks into integrated activities of complex infrastructures The definition of cloud computing encompassed a wide range of sectors and industries, including communities and enterprises, travel, healthcare, and agriculture (Culpa et al., 2021; Abhinava et al., 2013). The remarkable growth of this technology is expected to expose new institutions to a variety of effects and repercussions. In order to establish and nurture an elite ecology within the organization, the campus must integrate cloud computing technologies that may be safely accessible inside the electronic campus. The science department at the scientific departments of the university are dispersed around a large area, making it difficult to monitor, manage, or keep track of everything that occurs within a given department (Jasim, 2023). a 5D-IoT framework was built for heterogeneous IoT systems. To evaluate the data, it makes use of the semantic descriptions of sensor observations (Al-Gburi, 2022). The use of open-source tools and methods to deal with energy consumption in distributed smart homes has not yet used massive information and logical models. It is possible to overcome any barrier between utilities and customers while maintaining the energy demand response ratio using this study.

Here we propose to use the Internet of Things to check and control home appliances, as well as to use the web to computerize already-existing dwellings. The client can easily operate these household appliances via the internet thanks to our suggested structure. The pledge proposes a capable use of the Internet of Things used to scan and control home devices that use the World Wide Web. The home robotics framework uses useful tools as a user interface. They can also talk using organized home computing with Internet access, through strategies for low-power messaging traditions such as Wi-Fi. This quest to control home appliances goes by the methods of smartphones that use Wi-Fi as the messenger and raspberry pi as the server architecture. An IoT-based home monitoring and control system is an advancement that can remotely control gadgets and their monitors to automate the home and any real appliances (Pokric, 2015). It provides the facility with the ability to control a wide range of home appliances and ensures security.

2 Related Work

Solar PV is a clean, long-lasting energy source which generates energy from sunlight. The photoelectric effect occurs when photons are absorbed by certain materials (particles of light) and release electrons, resulting in an electric current (Nguyen, 2018). In (Raghul, 2022). Optimization of energy expenditure in certain circumstances. Energy expenditures have been exhausted. Built to reduce energy expenditure represented by the Service Level Agreement (SLA). There are two levels at the model level: the system level and the component level. The first is to lower the second-level implementation overhead by using the dynamic voltage energy control technology utilization algorithm., more demand to satisfy the demand. The outcome requires a large amount of energy. In (Jabbar, 2022), the field of cloud computing, a new model has been devised in order to oversee the virtual server, and initial verifications have been conducted. The system's capacity to balance the loads on the devices and so reduce energy consumption is one of its key benefits. The virtual servers are distributed around the network and are configured separately. The sustainability concerns of energy efficiency and economic viability are greatly impacted by this. The evolution of the user overall service usage through the creation of a cloud computing test platform is another significant benefit of cloud computing. Malaysia still needs to implement solar energy widely; currently, just a few solar farms have been installed in places like Ayer Keroh, Sepang, and Gam bang. The PV system uses PVs to convert sunlight into direct current (DC) electricity. It can operate as an independent (off-grid) or grid-connected power system. To ensure adequate and secure battery charging, the generated DC current will be used during the day to charge the battery using a voltage regulator. Research on weather and climate change has been crucial to the advancement of humanity since it enables us to foresee problems in a variety of industries, including aviation, agronomy, building, and medicine, among others (Tenzin, 2017). climatic variables must be measured in order to characterize ecosystems, construct precise and intelligent agriculture, characterize solar photovoltaic (PV) systems, and monitor agricultural systems. Due to the wide range of uses for such measures, commercial systems and open-source prototypes made up of inexpensive or specially constructed sensors that are connected and used with wireless communication networks have been developed. In turn, this makes it possible to gather data in real-time and to create platforms for processing and visualization that make data easy to interpret in the context of applications (Kingsley, 2017). In (Kolbe, 2021), Under certain circumstances, one of the most important benefits of cloud computing is the reduction in energy consumption. This work implements a updated timetables and resource allocation scheme aimed at lowering energy use. Based on this, a model has been developed to lower the energy spending as indicated by an SLA. The model consists of two layers: component and system levels. First, a new technique that reduces the difference between servers and virtual machines is used to optimize the system's energy consumption through the use of genetic algorithms. On the other hand, the second level uses during implementation, use dynamic voltage energy control technologies to reduce energy consumption. Thus, if user and level demands are satisfied, the energy expenditure can be raised. The outcomes demonstrated that the cloud computing algorithms may dramatically lower the energy consumption of the system when compared to other algorithms and in the same conditions. In (Fiandrino, 2015), Cloud computing on mobile devices the convergence of MCC and cloud computing to run programs with varying resources is examined. It also investigates the correlation technique that reduces energy consumption in data centers. Initially, the issue is posed as a distinct, arbitrary program that seeks to lower energy consumption and boost system productivity. with the use of a scalable dynamic programmable algorithm. Comparing the suggested algorithms to the Alternative Minimum Delay and SALSA policies, the results demonstrate that the latter two policies can increase energy usage by around 40%.

In (Wajid, 2015), Because it depends on knowledge, control, and effective use of energy and CO_2 measures to reduce energy consumption and CO_2 diffusion of infrastructure and cloud operations, as well as on the careful planning of uptime-adapted applications and technology, an idea is put forth that is closely related to the environment. The suggested concept has the potential to drastically cut energy costs and carbon dioxide emissions.

An open-source cloud server named ThingsSpeak.com and an easily available esp8266 Wi-Fi module serve as the foundation for the unique security architecture proposed in (Netto, 2019). This connects to the home's PIR sensor, which shows each person's disclosure on a constant basis. The At mega 328p microcontroller receives a flag from the PIR module when an intruder is detected, and the controller is linked to the Esp8266 Wi-Fi module, which is added to a prepared chassis. The PIR sensor sends a preset signal to the open-source cloud, which in any case displays an alert banner to clients via mobile device. According to (Pooja, 2017), smart home security is starting to play a significant role in modern families' and businesses' daily lives. Home security is closely related to us and includes individual security equipment and practices. The equipment will be doorways, alarms, lock frames and distinct types of sensors such as PIR sensors, temperature sensors, and gas sensors for non-positive status recognition. In (Basso, 2015), the authors presented a sensor-based dynamic pedestrian crossing system at traffic intersections. In (Luo, 2015), the authors presented power grid monitoring using an embedded web server. The system uses LPC2148 and an embedded TCP/IP Rabbit Core Module 5170. In (Dabbagh, 2015), Because of the current state of the economy, cloud computing service providers are searching for innovative methods to cut down on their energy usage. Services rendered using cloud computing have unique features that set them apart from conventional services. Because of this, there is a sharp increase in competition to save energy using the data centers' energy resources, since energy management technologies are centered around virtualization as a method for energy conservation. In (Tianshi, 2016), Energy efficiency has emerged as a key concern for data centers since cloud computing, which depends on readily available and shared computer resources, has become a viable model for service delivery via the Internet. Three layers—B Cube, D Cell, and Hypercube—are among the most popular types of data center components for which a new set of metrics was defined in this work. These indicators can be used to evaluate cloud computing communications system performance as well as anticipate data center energy efficiency.

All the studies mentioned above have limitations in terms of data collection, processing capabilities, and accessibility. While, in this work the Smart Weather Station based on a cloud platform aims to solve is the need for real-time and accurate weather monitoring and analysis.

3 Cloud Platform Architecture for Energy System Analysis

Three components make up the completely developed energy analysis cloud system, as depicted in Figure (1). Analysis of the energy system's physical infrastructure, cloud applications, and process management components (Michalakis, 2023). Infrastructure that is physically present includes data center infrastructure, which comprises servers, computers, power supply, storage space, and network hardware. Multiple degrees of computer services are offered for energy system analysis by the segment of cloud services for energy system analysis. Access verification, cloud computing, power cloud analysis, statistics, and tracking system organization, user data, guaranteeing the degree of application security systems and cloud services, etc. are among the challenges that the operations management component handles (Nadu, 2023). It also addresses the preservation of device security and service quality.

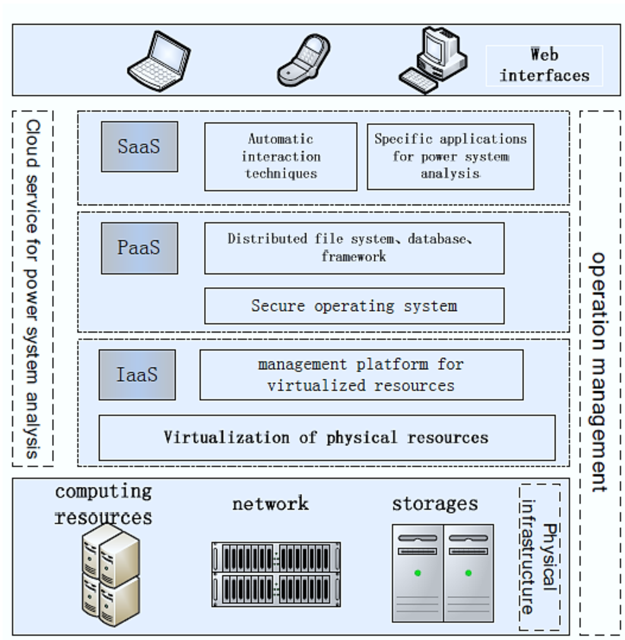

Figure 1: Shows the Framework for Power Analysis of Systems Based on Cloud Platform (Fiandrino, 2015)

Cloud Services for Energy System Analysis

The bulk of the company's core business consists of cloud services for energy analysis, which are mainly separated into three groups: infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS). The layer of IaaS creates a consistent IT environment for power system research by utilizing virtualization technologies, such as CPU, RAM, I/O, and network virtualization. It effectively achieves quick network connectivity and rapid virtual machine deployment through the use of virtualization technologies. The virtual image path can be used to store, publish, and remove the same corporation (Fahim, 2023), and the resource control division can be set up to control the entire virtualized resource system. PaaS services comprise the development and testing environment, the operating system, and the distributed database file system. The state security operating system is used to guarantee the security of the private cloud platform. It offers users an easy-to-use, unified development interface for parallel systems for large-scale computing, distributed databases, and bulk data processing. The success of power system big data processing will be ensured by implementing distributed storage management and document management using Hadoop open-source technology (Safa, 2016). Together with the Map Reduce framework for Hadoop and the well-liked MPI parallel programming paradigm in parallel computing, deploy the distributed programming framework on this foundation to create the parallel programming framework required in scientific computing. Incorporate intermediary components in line with the generally recognized guidelines for creating power grid applications. Utilize well-known software development kits and parts, such SKD (Helo, 2021), C, PHP, Python, and other widely used programming languages, in accordance with actual needs. Last but not least, a distributed interface for web development should be provided by the PaaS layer. SaaS layer services, which are mostly used by software consumers rather than developers, are related to the particular business of energy system analysis. Developers keep downloadable photos of related work on energy system analysis for cloud storage platforms. In order to make using the security access management component convenient for users, technologies including virtual machine automated deployment, sandboxing, interactive applications, and web rendering are provided (Feng, 2021).

Security, Real-time Factors, and Power System Analysis Cloud Platform Quality of Service

The private cloud infrastructure has been analyzed to ensure system data is protected. A relatively complete WAN has been developed within the Chinese power grid, which can be used to build a power system private cloud. Since the entire power system can be managed by connections to cloud storage and processing services, which provide complete physical separation, data protection is guaranteed. Moreover, each user is given a different visual experience in cloud computing, removing all connections from other visual environments. It's crucial to fully monitor and maintain the privileged virtual machine because it is used in the IaaS service layer to deal with other virtual machines Regarding the vulnerabilities in security caused by virtualization technologies; The platform uses AAA verification for entry its file of system, storage system, and applications. The access control system is placed at the PaaS/SaaS layer to monitor data management authority and access rights of different levels and types. (Jia, 2021).

The maintenance portion of the cloud platform has to be enlarged in order for the server security audit department to monitor system movements. The cloud system's default image does the same procedure, stores it, and then deletes it; The operating system, simulation environment, and even application functionality is preinstalled on the virtual machine image, also known as the schema; The execution time of the virtual machine can be greatly decreased by using the virtual machine template technique. To guarantee optimal real-time device utilization, applications of disk fault-tolerant technology, remote reconfiguration, and application recovery technology will cooperate. The assessment definition for IaaS layer services is split into two sections because there are multiple service requirements for varying levels of QoS cloud services. The first section covers the absolute minimum of services that cloud providers offer, like server availability, and the second section covers service response time. Consultation will determine the final SLA based on evaluation criteria for various specifications and the differing levels of implementation needs. The deterministic SLA provides service needs 100% of the time, while the probabilistic SLA, which is typically stated with the availability figure, promises customer wants with a given probability. Queuing theory-based model architecture load forecasting for PaaS and SaaS layer services, contrasting the hardware equipment's workloads, monitoring client demand and QoS measurements, adjusting the quantity of virtual machines utilized for the service, and confirming the division of the service's granularity (Ahmed, 2021).

4 Proposed System Design

It is crucial to collect information on the temporal dynamics of weather changes. In terms of weather monitoring, there are numerous options. Specifically, understanding climate factors is necessary for the service sectors to learn about humidity and temperature in the atmosphere. Monitoring wind power was a crucial need for building wind turbines. Airports regularly monitor temperature, humidity, and visibility for aircraft taking off and landing. The wind direction and velocity are necessary for low-speed aerial vehicles such as micro air vehicles (MAVs) and unmanned aerial vehicles (UAVs). This is to track an object on the ground or drop an object at a precise spot by knowing the actual wind direction and speed. (Kollolu, 2020; Abbas et al., 2023).

The first thing facing the designer in designing a specific system is choosing the appropriate types of equipment. This equipment should have the ability to handle the system requirements. Our system needs to control a specific environment by sensing parameters. This parameter, for example, is both the temperature and humidity. So, at the first selection, we need to select the type of sensor used in the system. The data stored in my cloud is accessed from anywhere, at any time by sending an HTTP request via the user's browser via the Internet. Architecture Project Overview of monitoring the weather information is showing in the figure 2 below.

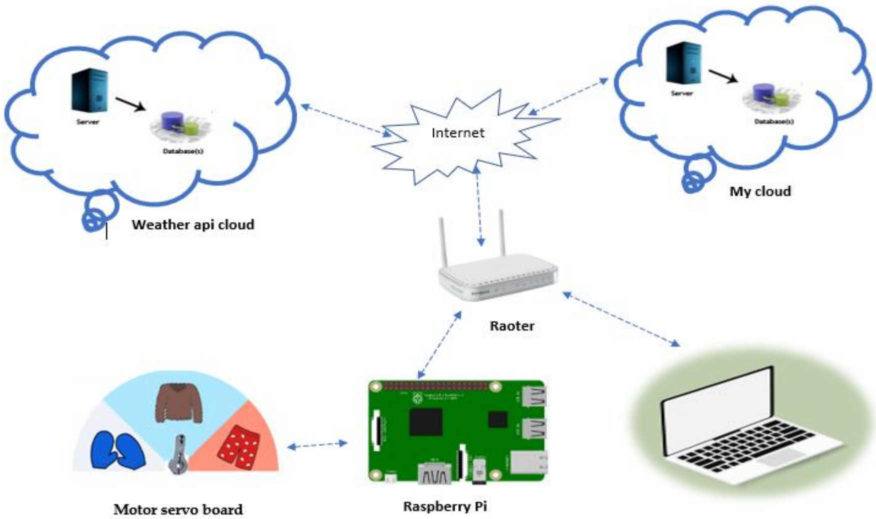

Figure 2: Proposed System Structure of Monitoring the Weather Information Based on Cloud Platform

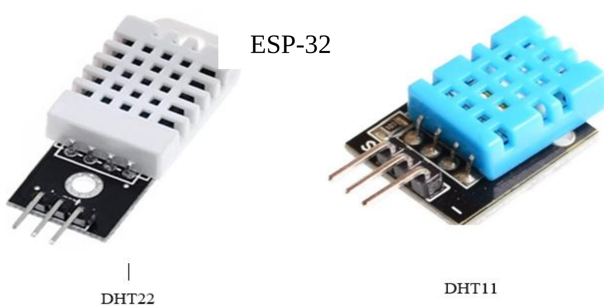

Figure 3: Temperature and Humidity Sensors

In this work, we choose DHT11. There are multiple types of temperature and humidity sensors. These types differ from each other in their specifications and prices. Fig. 2 shows some famous types compatible with the ESP-32 development board. Both of these sensors are economical in price and can handle the job indeed. The second choice of the system is the ESP-32 development board. In this subject, we have two primary choices for the board. Either using the ESP-8266 or the ESP-32.

The system consists of three main parts. The first part is the DHT11 temperature and humidity sensor. Its job is to sense the ambient temperature and humidity and then send the data to the second part represented by the ESP-32 microcontroller. The ESP-32 behaves as a web page server. It's programmed to include a web page used for two purposes. The first is to display the temperature and humidity reading. And the second is used to control three switches as the simulation turn on or off a specific application, such as light, heaters, fan, or other application. The third part of the system is the solar cell acting as a power supply. Figure 4 shows the system block diagram.

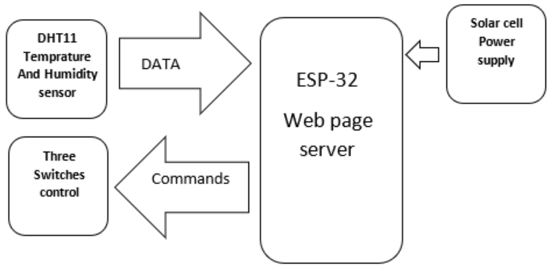

Figure 4: ESP-32 Web Server Block Diagram

5 Results and Discussion

In Figure 5, the sensors data of whether is displayed in the Connection terminal application in the Smartphone is with the help of ESP-32 Wi-Fi, we are considering both display temperature and humidity readings and allows the user to turn on or off a group of switches. This is an open-source cloud which can be accessed with the help of IP address that is (192.168.0.141 /automation. In Figure (6-A), the web page displays the information with all switches turned off, waiting to turn on by the user. In Figure (6-B), the first switch is turned on while the other switches are in the off state. Table. 1 shows the pin connection for the proposed system.

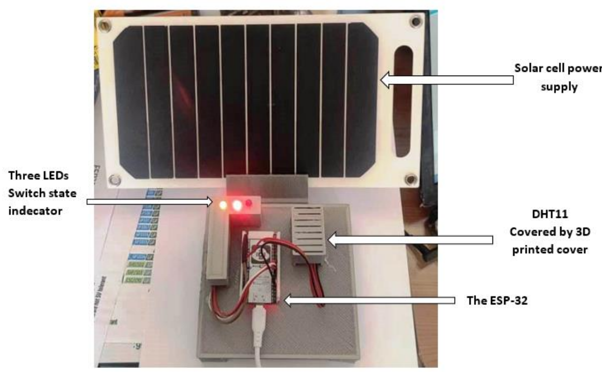

Figure 5: the ESP-32 Web Server System

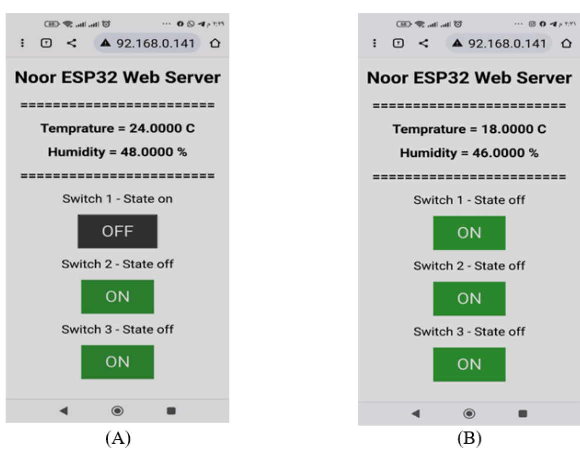

Figure 6: Designed Web Page on the ESP-32 used to Display Temperature and Humidity and to Control Switches

Table 1: Connection Terminals

ESP-32 PIN number	function
GND	Connected to LEDs negative terminal
25	First, switch LED positive terminal
26	second, switch LED positive terminal
27	Third, switch LED positive terminal
GND	The ground terminal of DHT11
3.3 V	Positive voltage DHT11 terminal
18	Information terminal of DHT11 sensor
ESP-32 USB PORT	connected to solar cells as a power supply

In this proposed system was built to monitor the weather, such as wind speed, temperature, and humidity, and to warn citizens in case of any sudden changes in weather information. The proposed system is mainly dependent on the Internet of things. After that we built two clouds that consist of a web server and a database that are connected via the Internet. The web server contains the software files responsible for processing the request that comes from ESP-32, and after that it sends a request to the database to store the weather information inside it. This data is accessed from anywhere and at any time to monitor the weather

6 Conclusion

Cloud computing has enabled people to access many of the things they desire in life. Included are other costs and resources in addition to safety and convenience. Numerous services that people need in their daily lives are given by cloud-computing. Security, comfort, price, and other resources are mentioned. In this study, a cloud-based system was created and used to deliver a specific service to control the consumption of electrical energy devices, including the capability to control, safeguard, and trace the electrical equipment used. three electrical appliances were used, and an Esp-32 web server app was employed as an assessment framework. Any of them are dependent on sensors (such as temperature and humidity sensors). As for the rest, the consumer can monitor how much energy is being used by turning off passive equipment where the quantity of current taken or energy expended is known. This allows him to spend less energy overall. The cloud-based technology in this research was developed and applied for providing a certain service in the public or commercial sector, including the capacity to oversee, safeguard, and monitor operational electrical equipment. This research discusses using ESP-32 as a web server with a web page that includes both display temperature and humidity readings and allows the user to turn on or off a group of switches. This search uses economic and available electronic components. This ESP-32 development board can also be used with different sensors, so the system does not depend on whether readings represented by temperature and humidity. But also, can include more applications according to the sensor types used.

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